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Memorandum

To	Michael Cheyne, PMP Third Runway Program Leader	Date	October 26, 2000
From	Jim Thomson, P.E., HNTB Mike Bailey, P.E., Hart Crowser Michael Kenrick, P.E., Hart Crowser		
Subject	Third Runway Embankment Infiltration		

Summary

Sometime ago, the Third Runway Design Team was asked to consider taking steps toward providing enhanced infiltration within the embankment. Because of the stormwater detention benefit infiltration provides, the team had already reviewed the possibilities of enhanced infiltration and believed the project could provide opportunity in the following ways:

- Use of flatter cross slopes on the airfield providing greater stormwater residence time on pervious surfaces.
- Longer water courses over pervious surfaces prior to stormsewer collection also increasing residence time.
- Use of a variety of naturally occuring fill materials allowing for some infiltration while continuing to provide stability.

Recently, the design team was asked to provide additional infiltration beyond what would occur from the design approach outlined above. We have evaluated alternatives, which would meet both design goals of enhanced infiltration and embankment stability. The design team believes that artificially increasing the amount of infiltration beyond standard design and construction practice for an embankment of this depth would increase the risk of instability, increase construction complexity and costs, and may result in adverse impacts beyond the embankment limits. We believe the benefit, which might be provided through enhanced infiltration, is out-weighed by the increased risks to the embankment.

Embankments that are designed and constructed for storm water retention, reservoirs, etc. are typically built as zoned embankments, with different soil material zones used to control seepage and provide necessary drainage or strength to accommodate the resultant pore pressures. The proposed Third Runway embankment is a type of zoned embankment, but its zones were designed to optimize support of the airfield pavement sections with minimum long term risk. The increased risks resulting from enhanced infiltration are:

- Increased risk of surficial slope stability problems related to seepage
- Increase risk of subgrade liquefaction base stability
- Increased construction complexity
- Long term maintenance issues

A more detailed discussion of the increased risks follows in the next section of this memorandum.

Bailey
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Details of Increased Risk

1. Increased Risk of Surficial Slope Stability Problems Related to Seepage

Side slopes for the proposed embankment are designed to be constructed of readily available soil fill, which can achieve the strength needed with conventional construction methods. The strength necessary for the fill depends on a number of factors, but mainly on the angle of the side slopes, drainage conditions, anticipated seismic loads and foundation conditions. Increasing the amount of water infiltrated into the embankment has the potential to reduce stability by increasing pore pressures. This would have three adverse effects:

- Increased risk of piping and erosion-related instability ("sloughing") of the embankment side slopes due to seepage forces and loss of support where the seep exits the embankment surface;
- Increased soil bulk density due to the added weight of water, which will contribute to the potential for failure of the embankment; and
- Decreased soil strength near the surface of the slope but within the embankment (the effective strength available from soil friction is less than the unsaturated total strength by an amount equal to the increase in pore pressure).

Making a commitment to a specific flow rate and flow timing (during late summer), would require a specific water volume retained. Soil engineering would need to be based on flow rate and not stability.

2. Increased Risk of Subgrade Liquefaction Base Stability

Native soils that provide the foundation for the Third Runway embankment generally consist of a layer of relatively loose to moderately dense sands and interbedded cohesive soils, overlying very dense or hard, glacially overridden soils. Typically there is a layer of groundwater perched on top of the more dense glacial soils, and in some areas this saturated soil zone is subject to significant strength loss during seismic shaking – a process referred to as "liquefaction". The design team has defined some areas where subgrade improvements (i.e., densification or replacement of the native soil) are needed to mitigate liquefaction.

Artificially increasing the amount of infiltration into the embankment would likely lead to an increase in groundwater levels below the embankment, and thus increase the risk and area of potential liquefaction. The extent of this change is difficult to predict and thus an increase in risk would result. (A portion of the additional infiltration is expected to discharge via the underdrain. However, the underdrain is designed to prevent build-up of pore pressures in the fill placed above the drain and will not prevent the water table beneath the embankment from rising to the level of the drain itself; i.e., to the existing ground level).

Potential adverse impacts of liquefaction include reduced embankment stability due to loss of soil shear strength, as well as potential vertical displacement or other ground disturbance (e.g., "sand boils") along the relatively level ground adjacent to the embankment. The potential for liquefaction of native soils adjacent to the embankment already exists, but the risk of occurrence and magnitude would be increased by raising existing groundwater levels, as a direct result of increased infiltration.

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3. Increased Construction Complexity and Cost

Specifications for embankment construction to date have included a range of soil fill materials in order to obtain cost competitive bids while supporting airfield pavement sections. Modification of the embankment to increase infiltration would increase complexity of construction and is anticipated to increase construction costs in one or all of the following ways:

- Soil fill used to enhance infiltration would need to be a select material, since the infiltration capacity of sand and gravel decreases rapidly as the percentage of clay and silt increases even moderately. Using bids from the current year for comparison, the cost of the Group 1, non-silty (or "freely draining") soil to enhance infiltration, compared with the more silty Groups 2, 3 and 4 soil used as common embankment fill is about 200 percent more expensive.
- Note that the cost difference presented above does not present the complete picture. Restricting the gradation of the fill material would restrict the number of sources that could supply it, and that along with an increase in the total amount of non-silty soil that needs to be used could possibly increase the unit cost. Further cost increases related to construction management and survey control would also probably occur in the event that placement is required to configure special infiltration zones within the embankment.
- Increased pore pressures within the embankment and liquefaction susceptible subgrade soils would need to be mitigated to achieve the same factor of safety as obtained for the embankment without enhanced infiltration. This mitigation could include use of higher strength embankment material and/or by increased subgrade improvements. Increased costs would result from using higher quality or more highly compacted fill soils; reinforcing the fill; and increasing the area of coverage and/or increasing the density of subgrade improvements within existing areas.

4. Increased Need for Long-term Maintenance and Associated Risks

There are a number of alternatives available that initially appear to provide some opportunity to increase infiltration into the embankment, such as increasing length between catch basins in grassed areas between pavement; infiltration swales; perforated pipes extending from catch basins; a surficial layer of plating sand, etc. All of these approaches are likely to require some degree of maintenance in order to prevent siltation, bacteriological clogging, and/or other problems to provide effective long-term functioning.

Drains in general need to have some means of being cleaned out, and this applies equally to soil zones used to promote infiltration and transmit seepage. There is virtually no way to maintain an infiltration system deep within an embankment. It is also worth noting that once the embankment has been constructed, there will be no way to detect or "unclog" a failed infiltration system deep within the interior of the embankment. Furthermore, a failed system will increase the potential for a stability failure within the embankment.